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2D:4D Digit Ratio

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2D:4D Digit Ratio:

Indicator of Sports and Gaming Participation in Males

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Introduction

The ratio of the second to fourth finger lengths has been studied an abundance of times, in an attempt to discover what it can possibly be a sign of. This 2D:4D (index finger:ring finger) digit ratio has been suggested to be a possible indicator for a number of traits, including athletic sporting success and visuospatial abilities (1). The second to fourth finger ratio is also thought to be related to gender identity and some sex-related characteristics such as motor, cognitive, and personality traits (2). Such traits include level of aggressiveness and one's inclination towards thrill and adventure seeking (3). Additionally, one study discovered that there is a significant difference between the average 2D:4D ratios of heterosexual men and homosexual men, indicating that this ratio is also possibly able to be a marker for sexual orientation in men (4). This digit ratio has also been studied to see if it is altered in those with certain disorders or diseases. In research done by Manning et al., it is found that children with autism have lower 2D:4D ratios than the normative population values (5). Seeing some of the various traits that this ratio can be a sign of, what then follows is discovering what alters these ratios from person to person.

There have been numerous studies done about the relationship between this 2D:4D ratio and androgen exposure during fetal development. The relative length of the fingers is established early in the gestation period, with the general ratios determined by the thirteenth week (6). *Hox* genes regulate the development of the digits, and different testosterone levels affect these genes (7). Free testosterone undergoes an androgen receptor-mediated mechanism to indirectly modify the *Hox* genes during development (8). These receptors are more prevalent in the fourth digit (9), so high levels of testosterone would likely cause the fourth digit to be longer than the second. This causes a low 2D:4D ratio, and is just one item of many that supports the conclusion that males tend to have a lower 2D:4D ratio than females (as they typically experience higher levels of free testosterone in the womb). Therefore, digit proportions are altered by testosterone *in utero*.

A study following digit development of fetuses found that not only is this digit ratio determined *in utero*, but also, like previously suggested, males tend to have a lower 2D:4D than females (10). This continues to indicate that a low 2D:4D ratio (index finger shorter than ring finger) means a person was exposed to more androgens in utero than someone with a higher ratio. This is further confirmed by research in which amniotic fluid is studied to see fetal testosterone and estradiol levels. Then, once the children turn two, their digit ratios are measured. Results show that individuals with low 2D:4D ratios have high fetal testosterone in relation to their fetal estradiol levels, and those with a high digit ratio have low fetal testosterone and high fetal estradiol (11). This negative association between fetal testosterone/fetal estradiol and the 2D:4D ratio further suggests that prenatal exposure to androgens affects digit length development.

More testosterone exposure could possibly also be related to competitiveness. Androgens are responsible for many male traits, such as development of the male reproductive system (12). Androgens stimulate development and growth of skeletal muscle cells (13), which aids in strength and athletics. In a study with teenage males and females, there is a negative association seen between the 2D:4D ratio and their composite measure of physical fitness (14). This may be due either to a higher level of athletic abilities or these individuals being more inclined to competitively participate in athletic events, both of which may be influenced by prenatal testosterone exposure.

This study was undertaken to see if there is a relation between this 2D:4D digit ratio and a person's level of competiveness in areas such as school, athletics, and gaming. It was aimed at seeing if competiveness is not simply learned, but inborn. Subjects were asked to complete a survey that was comprised of a series of questions aimed at discovering what types of activities they participate in, both academically and otherwise. These subjects also answered the questions included in the Revised Competiveness Index (15), and rated, on a scale of 1 to 5, their level of participation in sports within the last five years. The subjects had their right hands photographed, and the length of their second and fourth digits were measured using ImageJ software. These ratios were analyzed to find possible correlations between the subject's digit ratio and their answers to the aforementioned survey.

Methods and Materials

Participants

Before completing any part of the experiment, subjects read and signed an informed consent document. Additionally, before beginning this study, researchers were IRB certified to perform research on human subjects. There were 100 subjects total: 70 females and 30 males. All subjects were college students. Data was deidentified to ensure anonymity. Rather than names, codes signifying gender and participant number were assigned to subjects.

Competitiveness and Activity Survey

Subjects were given a survey that asked a series of questions, including: 1) What is your major? 2) Do you compete in sports/have you competed in sports in the last 5 years? 3) Do you competitively game (online games, Fantasy Sports, etc.)? 4) Do you feel a strong need to get better grades than your classmates? 5) Do you often feel the need to be the best at the activity at hand?

These subjects also answered the questions included in the Revised Competiveness Index (15), which has had follow up studies showing it to be a dependable indicator for competiveness as a trait and has a high test-retest reliability (16). The subjects were also asked to rate, on a scale of 1 to 5, their level of participation in sports within the last 5 years. The rankings were as follows: 1- no consistent sports participation, 2- small participation on and off through last 5 years, 3- moderate semi-consistent participation, 4-moderate-high consistent participation, 5- high level of participation in sports, both within last 5 years and currently.

All data for each participant were recorded in an Excel data sheet.

Digit Ratio Measurement

The participants had the upper portion of their right hands photographed, as it has been suggested that the 2D:4D ratio is most defined in the right hand (17). This was against a flat white surface with the palm of the hand facing up. Also in frame was a code that matched a code also written on the survey the subject filled out. The code signified the gender and number of the subject (e.g., female 26 had F026 in the picture of her hand and written on her survey). The length of their second and fourth digits were measured using ImageJ software. This was measured three times, and the average ratio was recorded in the Excel data sheet.

Analysis

The collected data was analyzed to find possible correlations between the subjects' average digit ratio and their answers to the aforementioned questions and sports participation scale. Relations between average 2D:4D ratio and score on the Competiveness Index were analyzed using a t-test to discover if there was a significant correlation. This was also done for the relationship between the ratio and whether the subject majors in science, business, or the humanities.

Results

The purpose of this study was to examine the relationship between prenatal testosterone and competitiveness by analyzing a subjects' 2D:4D digit ratio and their scores on the Revised Competitiveness Index, as well as their level of participation in various competitive activities (i.e., sports, school, and competitive gaming). To find this relationship, survey results and 2D:4D measurements were found for 100 subjects. As shown in Table 1, the average male 2D:4D ratio was 0.937, while the average female ratio was 0.961 (p=.008 by student's t-test). There was a larger range in the digit ratios of males than there was in female ratios, with the range being 0.22 for males and 0.18 for females. The male ratios also had a greater standard deviation than females, at 0.048 and 0.035, respectively.

	Average 2D:4D digit ratio
Male (n=30)	0.937
Female (n=70)	0.961
All (n=100)	0.954

Table 1: Average 2D:4D digit ratios for males, females, and all subjects combined. The difference between male and female digit ratio is statistically significant (p<0.05).

The 2D:4D ratio and scores on the Revised Competiveness Index did not have any statistical significance between them. The only somewhat strong trend shown was between males who scored in the 34-47 (out of 70) range versus those who scored in the 59-70 group. Though this relationship was not statistically significant, the p-value was 0.13, which does tend to suggest an association.

The average digit ratio of those (all genders) who answered “yes” when asked if they competed in sports within the last 5 years was 0.947, as opposed to the average ratio of 0.977 for those who answered “no” (Table 2). This relationship is very statistically significant (p=0.002), but is even more so when only males are considered (p=0.0004). The digit ratios of females who participate in sports are not significantly different than the ratios of females who do not participate in sports (p=0.57).

	Male Average 2D:4D (n=30)	**Female Average 2D:4D (n=70)**	**All Average 2D:4D (n=100)**
Competitively Game: Yes vs. No	**0.921 vs. .966***	0.970 vs. 0.959	**0.937 vs. 0.960***
Participate in Sports: Yes vs. No	**0.924 vs. 1.00***	0.958 vs. 0.969	**0.947 vs. 0.977***

Table 2: Average 2D:4D digit ratio of those who answered “yes” vs. “no” on if they competitively gamed or play sports. As denoted by the asterisks (*), there is statistical significance (p<0.05) in these categories for males, and also when all genders are combined and considered.

In addition to being asked in a yes/no format if they participated in sports, subjects were also asked to rank their sports participation on a 1-5 scale. In males, there was significance between the 2D:4D ratios of the following groups: 1 vs. 3 (p=0.047), 1 vs. 4 (p=0.033), and 1 vs. 5 (p=0.023) (Figure 1). Again, there was no statistically significant difference found between any of the groups for females. However, for all genders combined, there was statistical significance in the difference of the digit ratios for the 1 vs. 4 groups (p=0.01), as well as when 1s and 2s were combined and compared against the 4s and 5s combined (p=0.04).

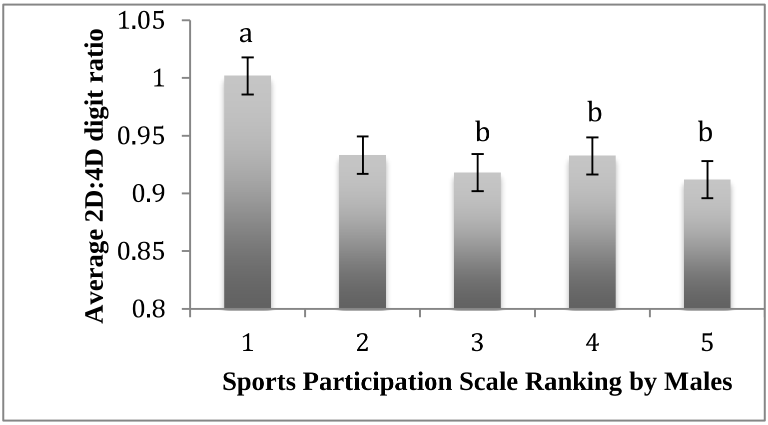

Figure 1: Average 2D:4D digit ratios of males (n=30) according to their ranking of level of sports participation within the past 5 years. There is a general decrease in digit ratio as the level of sports participation increases. An "ab" letter match notes statistical significance (p<0.05).

Participants also answered if they competitively game (online gaming, fantasy sports, etc.) in a yes/no format. The average digit ratio of the males that answered "yes" was 0.921, and was 0.966 for those who responded with "no" (p=0.01) (Table 2). When all genders combined were considered, there again was significance between these yes/no responses and digit ratio (p=0.009). However, there was no statistical significance when females alone were studied (p=0.5). There was no significant relationship between digit ratio and the yes/no answers to the questions regarding if the participant felt a strong need to get better grades than classmates or be the best at the activity at hand (p>0.05).

Finally, there was limited correlation found between 2D:4D ratio and the subject's major (Figure 2). All majors were categorized into one of five groups: science/math, business, allied health and education, social science, and humanities. When all genders were included, there was a significant relationship between the digit ratios of science/math versus humanities majors (p=0.049). Also, there was significance between the digit ratios of social science and humanities majors (p=0.004). There was very nearly statistical significance between social science versus allied health and education majors (p=0.055). When males alone were studied, there was no significance between the digit ratios of any of the majors. However, when females were studied, there was significant relationships between the 2D:4D of social science majors and humanities majors (p=0.02). The average digit ratio of a female social science major was 0.942, while the average 2D:4D for a female humanities major was 0.973. Though there was only limited significance found between majors, there did appear to be a trend, as seen in Figure 2. This trend shows that those majoring in the social and natural sciences tend to have lower 2D:4D digit ratios, as opposed to those who chose to major in the humanities.

Discussion

The difference between male and female 2D:4D digit ratios was statistically significant, as was the difference between the digit ratios of males who play sports versus those who do not. Males that competitively game had statistically significant different ratios than males that do not competitively game. Those who major in the social and natural sciences tend to have lower digit ratios than those who major in the humanities. Though the 2D:4D digit ratio was not found to be an indicator of competitiveness as a trait as expected, according to the Revised Competitiveness Index, it does seem to be a marker for participation in some competitive activities for males. Male and female 2D:4D digit ratios having a statistically significant difference between them supports the findings of previous studies that suggest this digit ratio is a sexually dimorphic trait, and that male ratios are significantly lower than female 2D:4D ratios (10, 18). Though there was significance in average digit ratios between the genders, there was no significant relationship found between these average 2D:4D ratios and scores on the Revised Competiveness Index. Additionally, there was no significant relationship between the digit ratio and answers to the questions concerning if the subjects felt the need to do better than their classmates or be better at the activity at hand. This suggests that no correlation is present between testosterone levels *in utero* and competiveness as a trait. However, there was significance found for digit ratios of males who play sports as opposed to those who don't, as well as between those who play low amounts versus high amounts of sports. The significance with physical activity but not competiveness as a trait further suggests that competiveness may not be linked to physical fitness, as it has been proposed that the 2D:4D ratio is, in fact, related to physical fitness (14).

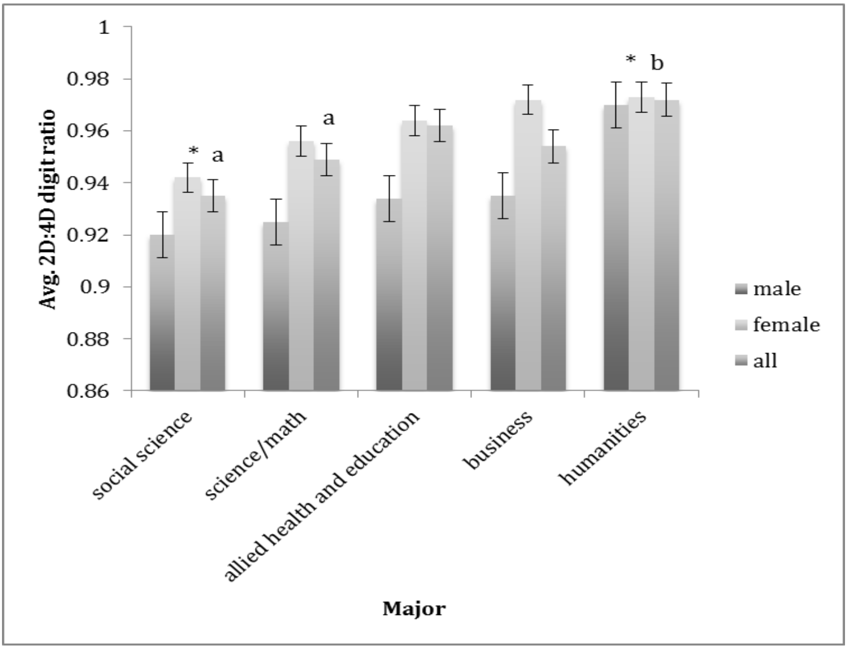

Figure 2: Average 2D:4D digit ratios according to gender and major. There is a general increase in digit ratio as one moves from social sciences towards humanities, but only a few categories show statistical significance (where p<0.05). For females (n=70), there was statistical significance between the average digit ratios of social science majors and humanities majors (denoted by the asterisk [*]). There was no significance for males (n=30). For all genders (n=100), there was statistical significance between social science majors and humanities majors, as well as science/math majors and humanities majors (an "ab" letter match notes statistical significance).

Although females were the majority of the participant pool, female digit often did not vary greatly from one group to another. Apart from one statistically significant difference between female social science and humanities majors, all statistically significant data was between male ratios or when all genders were considered and compared. The fact that there was this significance between the ratios of males that play sports versus those who do not, but not between females of these categories, could be attributed to the fact that there seems to be a difference in the societal pressure males receive regarding participating in sports and the pressure females receive. Males tend to get more encouragement and support to be highly involved in sports than females do (19). There being significance between actual levels (1-5 scale) of sports participation in males but not females is similar to the findings in one study that found the 2D:4D ratios of females who were professional gymnasts did not significantly differ from those of sedentary, non-athletic females (20). Although there is a difference in physical ability between these two groups, it did not translate to different digit ratios. However, another study found that competitive rowers who had smaller 2D:4D ratios had faster rowing times than those with larger ratios (21). This may not be translatable to effects of *in utero* testosterone exposure, but instead could possibly be due to advantages of certain body or limb dimensions that improve sporting performance (22). These advantages can be better applied in one sport over another.

This variance in significance found in males versus females could also be related to the reason behind participating in sports. As suggested in a previous study, there could be different motivation behind sports participation between males and females. College students were asked to rank their motives behind playing sports. Males ranked the number one reason for sports participation to be for the competition, while females ranked affiliation first, with competition being ranked the fourth highest motivating factor (23). This difference in motivation behind playing sports helps explain why there was significance between average digit ratio and sports participation in males, but not females. It also suggests that in males, competiveness may be able to be linked to the digit ratio, which goes against other findings in our study. These conflicting results show that one cannot use 2D:4D digit ratio as a marker for competiveness, but may be able to use it as a marker for likelihood that a male will participate in typically competitive activities.

In regards to academic majors, there was significance found only between a couple categories. A higher pool of data may have led to more categories being significant with 2D:4D digit ratio. While there were some significant differences between the digit ratios of certain majors, it is difficult to assume that the choice in academic major is largely influenced by competitiveness itself. The 2D:4D ratio may represent a different quality that attracts a person to a certain major. For example, Manning concluded that men with higher 2D:4D ratios have higher phonologically-based and semantically-based verbal fluency (24). This aptitude for language could explain why those with a higher average 2D:4D may be inclined to major in an area that applies language more, such as the humanities (shown to have highest average 2D:4D ratio in our study). Therefore, 2D:4D could be an indicator of other capacities that are beneficial for certain majors.

To improve this study, we could have increased our sample size. A larger sample size of both genders could have led to a higher amount of statistically significant results. Some categories (such as the lowest scoring group for the Revised Competiveness Index) only had one or two subjects, which is not a large enough data pool. Also, Xavier University students were the primary subjects in this study (with a very small amount of University of Cincinnati students), and are possibly not representative of the overall college population. There may be a bias within this candidate pool, so expanding it to many other schools, as well as possibly high school and graduate students as well, may have given a more clear picture of the connections.

Overall, this study demonstrates that the 2D:4D digit ratio is not a reliable marker for competiveness as a trait, suggesting that exposure to different levels of testosterone *in utero* does not affect competitiveness later in life. However, our findings do suggest that, in males, this digit ratio may possibly be useful as a sign of participation in sports and competitive gaming. Future studies will likely want to look further into the psychology behind what leads one to participate in athletics at varying levels, as well as why there is this significance only in males and not females. Additionally, one could study if the relationship between digit ratios and majors is different at universities with very competitive acceptance statistics as opposed to universities with low admission standards.

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